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east of Pikes Peak, discussing the *Bouteloua* formation as to its structure. Aven Nelson publishes 15 new species of seed plants from the Rocky Mountain region. George J. Peirce gives an account of *Anthoceros* and its Nostoc colonies, showing the fallacy of Prantl's argument that because cavities and hairs do not develop in the usual way except where the colonies are, the liverwort must profit by such an association.

DISCUSSION AND CORRESPONDENCE.

GLACIATION IN THE SONORAN PROVINCE.

TO THE EDITOR OF SCIENCE: In the current number of SCIENCE¹ Dr. Frederick J. H. Merrill directs attention to moraine-like accumulations of debris observed by him at a number of localities in northern Sonora and southern Arizona and New Mexico; of which accumulations part are well known to me—though my provisional interpretations differed from those of Dr. Merrill. The district is too extensive and too little known to warrant broad generalizations or to justify negation of the suggestions offered by so acute an observer as Dr. Merrill; yet future observers may be aided by the alternative suggestions growing out of my own observations in half a dozen journeys in the saddle (with others by rail and stage) through the Sonoran province.

So far as my observations go, the more extensive debris accumulations of the type described by Dr. Merrill (including those in the borrow-pit near Nogales and thence southward to Imuris) are confined to districts of late Mesozoic or Cenozoic vulcanism; while in some cases the accumulations appear to pass both horizontally and vertically upward into undoubted volcanics, much as the tuff beds underlying each table mountain in California grade into more firmly lithified lava sheets. Concordantly, my interpretation of the debris accumulations was that they were originally, and sometimes are now, volcanic tuffs and breccias much like those found further northward along the Pacific coast save that the brecciated structure is more striking than I have seen elsewhere. Frequently the breccias and lava sheets overlie massive blue

limestones undoubtedly equivalent to the vast Mesozoic (Cretaceous and Jurassic) limestone series of northeastern Mexico, and probably equivalent to the shale-mixed limestones of the Sierras, especially in southern California; and within a few miles of the borrow-pit south of Nogales (by which I once had occasion to camp for three days while awaiting official documents from Mexico) there are considerable exposures of this limestone, weathered as usual into the peculiar rugose surface—miniature mountain ranges and valleys—found by Hill and others to be characteristic of the Mesozoic limestones in the eastern Sierra Madre. The calcareous deposits are seen in places to rest (and probably everywhere lie) unconformably on granites, which in western Sonora and southwestern Arizona are of wide extent; yet neither on the limestone nor on the granitic terranes have I observed such debris accumulations as those so characteristic of the Imuris or Opodepe valley. Certain of the accumulations in this valley seemed to me well worthy of critical study as breccias primarily volcanic though accumulated in part by concurrent aqueous agencies, and recording in themselves a peculiarly complex volcanic history; for in several sections there are imbedded in the clay-like matrix angular boulders yards in dimensions, sometimes containing included boulder-like masses feet across, themselves made up of brecciated constituents inches or less in diameter. A part of the heterogeneous accumulations both in Imuris Valley and elsewhere were interpreted by me as rearranged breccias transported to limited distances and redeposited by sheetfloods or other freshets during the rather remote periods in which the lava sheets and tuff beds were newly exposed to surface erosion. In this connection it is to be noted that the province in question is the type region for sheetflooding, and that both the lower slopes of the sierras and the intervening plains are shaped by this agency; and also that sheetflood deposits are normally heterogeneous and ill-assorted accumulations of coarse and fine material, seldom perceptibly stratified or graded from coarse to fine either horizontally or vertically in the single section.

¹ Volume XXIV., pp. 116-118.

My interpretations were influenced by what seemed to me negative evidence both in topographic forms and in surficial materials throughout the lower ranges and intervening plains of western Sonora and southern Arizona. I have ridden over and camped on the country between Arivaca and Sopori (mentioned by Dr. Merrill), where the erosion forms assumed by the widespread tuff beds often simulate morainal deposits in general landscape effects, without finding indications of glacial agency either in deposits or in minute topography; while over the more elevated remnants of eroded ranges and among the lower slopes of the more rugged sierras most of the topographic forms impressed me as not merely water-cut but carved in that peculiarly acute fashion characteristic of the margins of sheetflood plains. Some of these plains are indeed diversified, especially toward the mountain margins, with both basin-shape depressions and debris-heaps, the latter frequently near the valleyward extremities of the former—the basins having been originally places of concentrated flow of the (generally dwindling) sheetfloods, and the debris-heaps the delta-like accumulations by which the localized corrosion was originally checked; though the heaps usually outlast the basins, especially when composed largely of obdurate rock-fragments, and form a type or genetic class of those natural mounds which are of late attracting much attention. The region is one of distinctively significant geomorphy; for it is not only the type district of sheetflood erosion, but comprises an extensive area of retrogressive carving due to a southwestward tilting—an area in which the general divides seldom coincide with the axes of the sierras but run far out on the low-lying plains between, circumscribing the head slopes of waterways (of which Rio Seco and Rio Bacuache are types) that have retrogressed northeastward entirely through the ranges in which they originally headed. Several examples of this remarkable retrogression were surveyed and mapped in detail by Willard D. Johnson in connection with that expedition which yielded his notable map of Seriland published in the *National Geographic Magazine* and also

in the Seventeenth Annual Report of the Bureau of American Ethnology; unfortunately, these surveys have not yet been published. During this same expedition Mr. Johnson worked over most of the surface and ascended most of the crests along the valleys lying next west of that of the Imuris; but neither he nor I noted ice-shaped topography anywhere in the region. Of course, any negative inference is worth far less than the positive inductions of a geologist familiar, like Doctor Merrill, with such glacial topography and deposits as those of northeastern United States; yet it is worthy of consideration pending more extended surveys than have thus far been found practicable in the Sonoran province.

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THE EARTHQUAKE AND PROFESSOR LARKIN.

In the *Open Court* for July, 1906, is a remarkable account of 'The Great San Francisco Earthquake,' from the pen of Edgar L. Larkin, of the 'Lowe Observatory on Echo Mountain,' otherwise professor of astronomy and geology in the University of the Sunday Supplement.

Professor Larkin came to San Francisco immediately after the earthquake of April 18. In a day or two he was able to discover a number of things which had escaped the notice of the local geologists, Lawson, Branner, Gilbert, Campbell, Davidson and others, constituting the official State Earthquake Commission.

Professor Larkin says: "One of my objects in leaving the peace and quiet in the observatory on the mountain, to make a five-hundred-mile journey to the stricken city, was to study the action of the earthquake in the great cemeteries. The fallen columns write the history of the convulsion in stone." To his surprise he found that "the half dead made their homes with the dead. Weak and wan girls played with the marble angels. * * * One desolate family found shelter in a beautiful sepulchre while the sufferers rested their heads on lowly graves." This was the more remarkable, for, as Jerome Hart suggests in the same connection, there is in California a